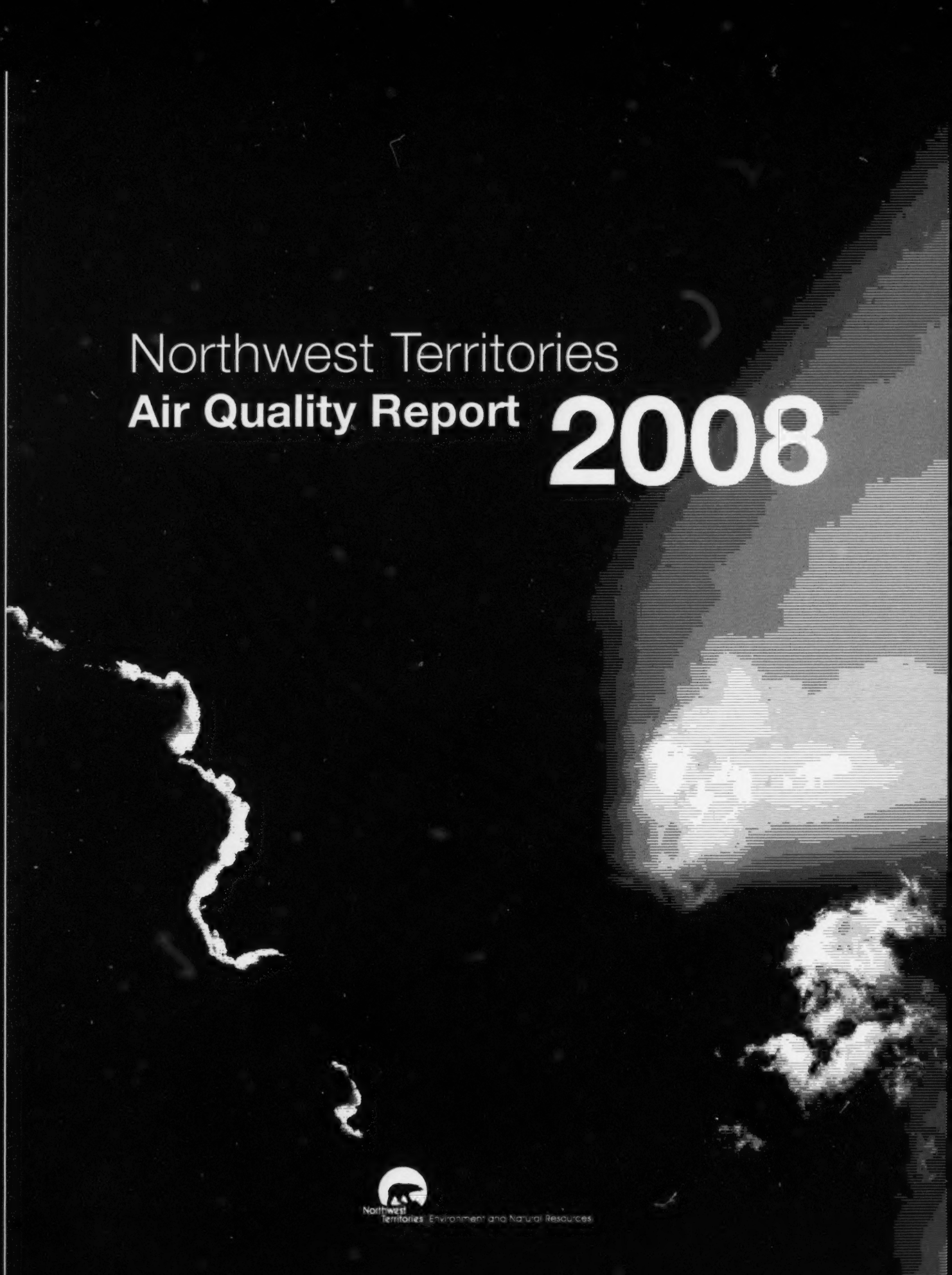
Northwest Territories
Air Quality Report 2008



Northwest Territories Environment and Natural Resources

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INTRODUCTION

The Environment Division (ED) of the Department of Environment and Natural Resources (ENR) monitors air quality in the Northwest Territories (NWT). ENR maintains and operates the NWT Ambient Air Quality Monitoring Network, consisting of four monitoring stations located in Yellowknife, Fort Liard, Norman Wells and Inuvik. Each station is capable of continuously sampling and analyzing a variety of air pollutants and meteorological conditions. The Yellowknife and Inuvik stations are operated in partnership with the National Air Pollution Surveillance (NAPS) program – a joint federal/provincial/territorial monitoring network tracking urban air quality trends throughout Canada.

ENR also monitors acid precipitation at Snare Rapids, in cooperation with the Canadian Air and Precipitation Monitoring Network (CAPMoN), and conducts seasonal particulate sampling at Daring Lake.

The 2008 Annual Air Quality Report summarizes the air quality information collected in 2008, along with some discussion of trends. The report also provides information on network operations, the air pollutants monitored and the air quality standards used in assessing the monitoring results. Further information, including 'almost real-time' air pollutant readings, can be found by visiting the NWT Air Quality Monitoring Network web site at http://lisin.rwed-hq.gov.nt.ca/NWTAQ/NetworkSummary.aspx

After reading this report, if you have questions or require further information, you can contact:

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This report is also available on the Internet at www.enr.gov.nt.ca/eps/environ.htm.

OPERATIONS (NETWORK)

The NWT Air Quality Monitoring Network consists of four permanent monitoring stations located in Yellowknife, Inuvik, Fort Liard and Norman Wells. The stations are climate-controlled trailers and include state-of-the-art monitoring equipment capable of continuously sampling and analyzing a variety of air pollutants and meteorological conditions. Pollutants monitored vary by station but include sulphur dioxide (SO_2), hydrogen sulphide (H_2S), fine particulate ($PM_{2.5}$), particulate (PM_{10}), ground level ozone (O_3), carbon monoxide (CO) and nitrogen oxides (NO_x) as well as wind speed, wind direction and temperature. For additional information on air pollutants see Appendix B.

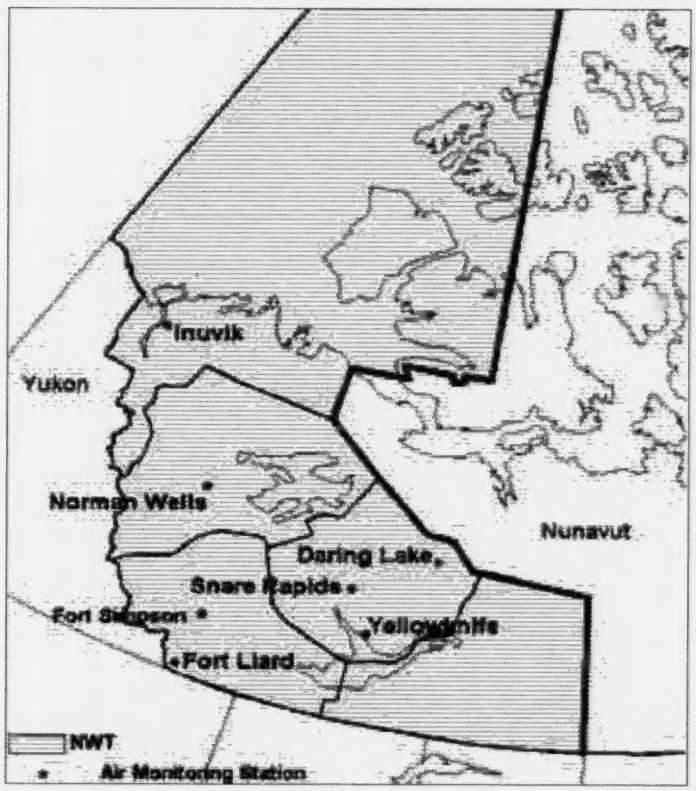


Table 1 shows the breakdown of the NWT Air Quality Monitoring Network by substances and meteorological parameters monitored at each station.

Table 1

Substances Monitored by Station											
Stations	**Particulate Matter**			**Gaseous**					**Precipitation**	**Meteorlogical Monitoring**	
	TSP – Particulate	$PM_{2.5}$ – Fine Particulate	PM_{10} – Particulate	SO_2 Sulphur Dioxide	H_2S Hydrogen Sulphide	NO_x Nitrogen Oxides	O_3 Ground Level Ozone	CO Carbon Monoxide	Acidic Deposition	Wind Speed and Direction	Air Temperature
Yellowknife	√	√	√	√		√	√			√	√
Inuvik		√	√	√	√	√	√			√	√
Norman Wells		√		√	√	√	√			√	√
Fort Liard		√	√	√	√	√	√			√	√
Snare Rapids									√		
Daring Lake		√									√

Using a sophisticated data acquisition system (DAS) and communications software, data from each station is automatically transmitted every hour via telephone line and government Intranet to ENR headquarters in Yellowknife. This allows almost real-time review of community air quality by ENR staff. The data also undergoes a series of 'on the fly' validity checks before being archived by ENR's data management, analysis and reporting system.

The Yellowknife and Inuvik stations are part of a larger national network monitoring the common or criteria air pollutants in urban centres across Canada. The National Air Pollution Surveillance (NAPS) Network is a joint federal/provincial/territorial program, incorporating approximately 290 stations located in 175 communities, to monitor the same particulate and gaseous substances as those sampled in Yellowknife and Inuvik. Data from the two NWT stations, along with data from other cities, is summarized and assessed, with results published in the NAPS annual data reports available at http://www.etc-cte.ec.gc.ca/publications/napsreports_e.html.

The NAPS Network has a stringent quality assurance/quality control (QA/QC) program to ensure Canada-wide data is comparable. Participation in the NAPS program requires ENR to follow these QA/QC procedures at the Yellowknife and Inuvik sites. ENR, in turn, applies these procedures at the other stations.

The Fort Liard and Norman Wells stations (and, until recently, the Inuvik station) are territorial stations that were set up in response to increasing resource development activity in the NWT and the potential for the associated emissions to affect air quality. The NAPS Inuvik station still fulfills its original territorial goals, along with its national urban monitoring objective. The primary territorial objective of these stations is to establish baseline levels of SO_2, H_2S, NO_x, O_3 and PM ahead of development as well as track the trends and cumulative impacts from source emissions should they occur.

ENR, with assistance from NWT Power Corporation staff, operates an acid precipitation collector at the Snare Rapids hydroelectric site. Daily rain and snow samples are collected and forwarded to the Canadian Air and Precipitation Monitoring Network (CAPMoN) for analysis. CAPMoN is a non-urban monitoring network with 28 measurement sites in Canada and one in the United States. Unlike NAPS, CAPMoN locates sites to limit the effect of anthropogenic sources. Most sites are remote and data is considered representative of background values.

ENR collects fine particulate data at the Daring Lake Tundra Ecosystem Research Station during the summer to establish typical background concentrations in the NWT. This research station is part of a circumpolar initiative called the Polar Continental Shelf Project and is designed as a research facility to conduct long-term research and monitoring of the tundra ecosystem.

Table 2 shows all of the various government affiliations involved with all of the monitoring stations.

Table 2

NWT Air Quality Network			
	Partnership/ Contract	**Stations**	**Network**
Environment and Natural Resources – Environment Division		Yellowknife and Inuvik	Environment Canada / Environnement Canada National Air Pollution Surveillance
		Fort Liard and Norman Wells	Northwest Territories stations
	NWT Power Corporation	Snare Rapids	Environment Canada / Environnement Canada Canadian Air and Precipitation Monitoring
	NWT Tundra Ecological Research Station	Daring Lake	Northwest Territories stations

Air quality monitoring in the NWT has evolved over time, beginning with a single TSP monitor in Yellowknife in 1974 and progressing through various monitoring locations and equipment to reach the current stage of development.

Appendix A traces the history of air quality monitoring in the NWT.

DEVELOPMENTS IN 2008

The Fort Liard station collected its first full year of ozone data. All four air monitoring stations now measure ground level ozone. Aside from the continual operation and maintenance of the Air Quality Monitoring Network, there were no significant developments to report in 2008.

FUTURE PLANS

ENR will be upgrading the existing air quality data management, analysis and reporting system to a new version. This will include replacing the existing traditional data loggers with PC-based industrial loggers. Continuing modifications will be made to the Air Quality Monitoring Network web site based on user comments and feedback. The web site will also be modified to the latest architecture. The web site is available at http://lisin.rwedhq.gov.nt.ca/NWTAQ/NetworkSummary.aspx and links with the data management, analysis and reporting system provide public access to 'almost real-time' air quality data for each monitoring location. Access to archived data is available by querying the database using web-based tools. The web site also provides additional information on the Government of the Northwest Territories (GNWT) Air Quality Monitoring Network, air pollutants and monitoring equipment as well as links to monitoring information collected in other jurisdictions.

A continuous PM_{10} monitor will be added to the Norman Wells station to complete the particulate monitoring installations throughout the network.

An ultra-low level CO analyzer will be installed at the NAPS designated Inuvik station following additional testing by Environment Canada.

The Snare Rapids air monitoring station will be replaced with a larger, climate-controlled shelter and relocated to a different site.

NWT AIR QUALITY STANDARDS

The GNWT has adopted a number of concentration limits for protection of ambient (outdoor) air quality in the NWT. These limits apply to selected pollutants and are contained in the "Guideline for Ambient Air Quality Standards in the Northwest Territories", established under the NWT *Environmental Protection Act*. They are summarized in Table 3 below.

The NWT standards are used in the assessment of air quality monitoring data as well as determining the acceptability of emissions from proposed and existing developments. Where NWT standards are not available for a particular pollutant, the Canadian National Ambient Air Quality Objectives (national standards) or limits established in other jurisdictions are used.

Table 3

NWT Ambient Air Quality Standards		
Parameter and Standard	**Concentration ($\mu g/m^3$)***	**Concentration (ppbv)****
Sulphur Dioxide (SO_2)		
1-hour average	450	172
24-hour average	150	57
Annual arithmetic mean	30	11
Ground Level Ozone (O_3)		
8-hour running average	127	65
Total Suspended Particulate (TSP)		
24-hour average	120	
Annual geometric mean	60	
Fine Particulate Matter ($PM_{2.5}$)		
24-hour average	30	

* Micrograms per cubic metre
** Parts per billion by volume

The "Guideline for Ambient Air Quality Standards in the Northwest Territories" provides additional information on the application of the NWT standards and the pollutants of concern. For additional information on air pollutants see Appendix B.

YELLOWKNIFE AIR QUALITY

ENR, in partnership with the Canadian NAPS Program, operates the air quality monitoring station in Yellowknife.

This station is located at the Sir John Franklin High School and continuously monitors all criteria air pollutants O_3, SO_2, NO_x, CO, fine particulate ($PM_{2.5}$) and coarse particulate (PM_{10}). The station also monitors wind speed, wind direction and temperature, which assists in identifying possible sources of unusual or elevated readings.

Additional non-continuous monitoring at the station consists of a TSP (dust), High Volume sampler (Hi-Vol) and a Partisol Dichotomous fine particulate sampler, formerly located on the roof of the Post Office until 2005.

Sir John Franklin Station

The air quality monitoring results from the consolidated station at Sir John Franklin are discussed in the following sections, with historical particulate data from the old Post Office site included where applicable.

Total Suspended Particulate (TSP)

Yellowknife's greatest source of TSP is dust from roads, especially in the spring when the snow cover disappears and exposes winter sand and gravel applications on city streets to the effects of wind and vehicle disturbance. Forest fires, mining activities and combustion products from vehicles, heating and electricity generation also raise TSP levels.

Every six days on a predetermined schedule, TSP samples are collected over a 24-hour period (midnight to midnight) using a Hi-Vol air sampler. The sampler draws a measured volume of air through a filter to collect the suspended particulate. The filters are sent to Environment Canada's NAPS laboratory in Ottawa for analysis. TSP is measured as the weight of the particles collected on the filter divided by the volume of air drawn through the filter. Results are expressed in micrograms of particulate per cubic metre of air ($\mu g/m^3$). Arsenic levels are also determined in the samples collected.

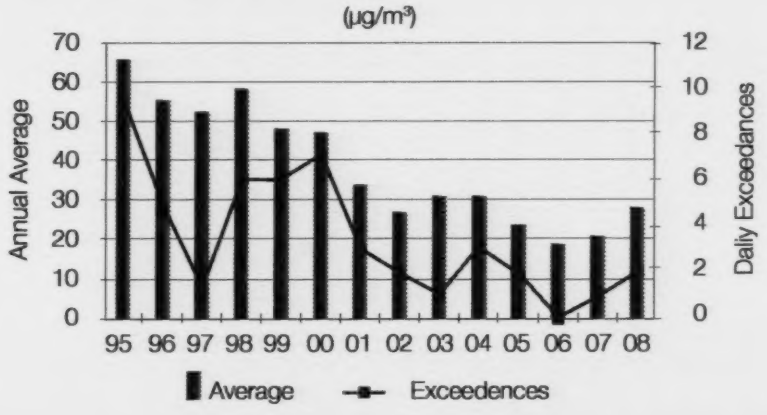
Table 4

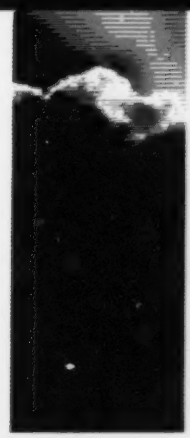
	Sir John Franklin		
	2007	**2007**	**2008**
µg/m³	TSP	Arsenic	TSP
Highest (24-hour)	121	.115	191
Lowest (24-hour)	2	0	4
Annual Average	21	.002	28

Fifty Hi-Vol air samples were collected during 2008. Table 4 summarizes the 2007 and 2008 TSP results, including the annual average (geometric mean) as well as the 2007 arsenic results. The 2008 arsenic data was not available for the release of this report due to analytical delays at the NAPS laboratory.

The bars in Figure 1 track annual average TSP levels in Yellowknife over the last decade (Post Office station 1995 to 2005; Sir John Franklin station 2006 and 2008). In 2008, the annual average was 28µg/m³. This is well below the NWT annual standard of 60µg/m³.

Figure 1: Yellowknife Annual TSP



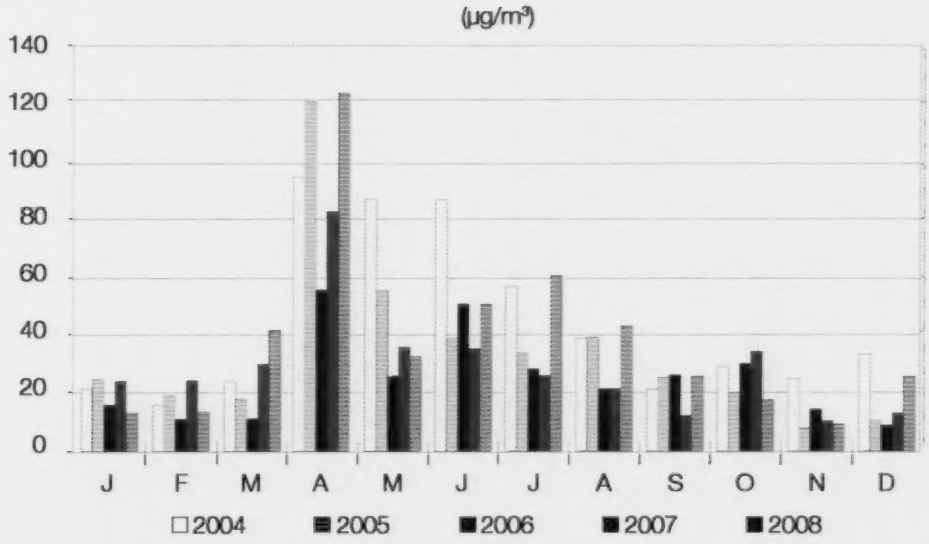


The line in Figure 1 shows the number of times during the year that the NWT 24-hour standard (120µg/m³) was exceeded. There were only two exceedances in 2008.

Since the early 1990s, dust conditions in Yellowknife have improved – largely due to the City of Yellowknife's efforts to clean roads throughout the spring and summer as well as ongoing paving of gravelled areas. The overall downward trend in annual TSP levels observed in the late 1990s and early part of the current decade appears to have levelled off in recent years. The recent annual average values may be approaching the lower limits achievable by the City's dust mitigation efforts and represent typical baseline readings. The fluctuations within the recent range of annual readings likely reflect the typical annual variations due to weather conditions and the intermittent sampling schedule.

Figure 2 tracks the average TSP level for each month for the last five years and clearly demonstrates the effects of springtime dust events. 2008 monthly averages followed the usual pattern, with higher TSP levels in April through July.

Figure 2: Yellowknife Monthly TSP



Fine Particulate ($PM_{2.5}$) and Coarse Particulate (PM_{10})

ENR uses two methods of sampling the smaller size fractions of PM in Yellowknife – a filter-based Partisol Dichotomous sampler and a Beta Attenuation Mass Monitor (BAM). The BAM methodology provides continuous, almost real-time (hourly) analysis of particulate concentrations, while the Partisol samples on a 24-hour basis every six days. The Partisol sampler simultaneously collects both the 2.5µm, and less, and the 2.5 to 10µm particulate size fractions on a filter media. The filters require laboratory analysis to determine particulate concentrations and, unlike the BAM, do not provide timely information for real-time air quality assessment. However, the filters can also be analyzed for a whole suite of additional parameters, including metals. The Partisol compliments the BAM in that particle identification can be determined, which provides more in-depth information about fine particulate. There are two BAMs operating at the Yellowknife station; one measures $PM_{2.5}$ while the other measures PM_{10}.

Seven $PM_{2.5}$ BAM readings at the Sir John Franklin station in 2008 exceeded the NWT 24-hour standard (30µg/m³). These exceedances were influenced by forest fire smoke. They occurred in July and coincided with forest fires burning in the North Slave region near Hardesty Lake as well as fires near Behchoko. Review and analysis of the results, and wind information from the Sir John Franklin station and other meteorological stations, clearly indicated the effects of fine particulate transport predominantly from these fires.

Figure 3: 2008 Yellowknife $PM_{2.5}$

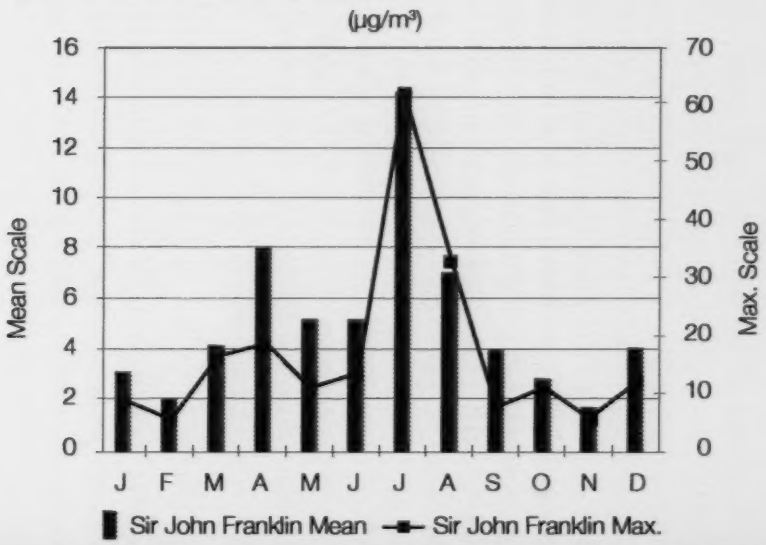


Figure 3 shows the monthly averages and daily maximums measured at the Sir John Franklin station in 2008. The highest daily maximum concentration was 62µg/m³. The highest hourly concentration recorded was 222µg/m³.

Figure 4: 2005 to 2008 Summary Yellowknife $PM_{2.5}$ BAM

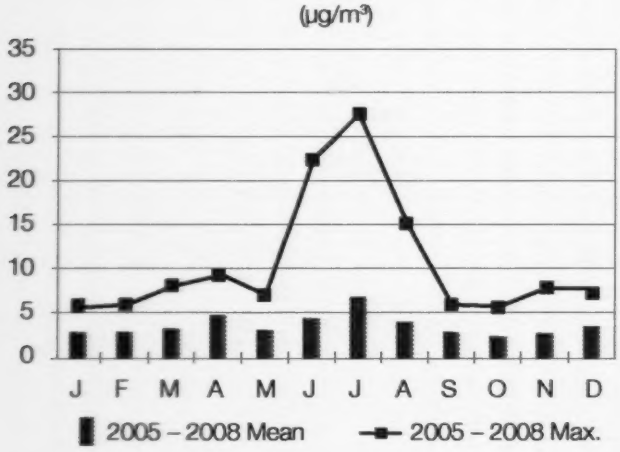


Figure 4 summarizes the $PM_{2.5}$ BAM data over the last four years, showing the overall mean and overall daily maximum for each month. Overall means for each month are low and very consistent ranging from 2 to 7µg/m³, with an increase in July, which reflects the influence of forest fire events. The June, July and August maximums were a direct result of smoke from forest fires. If the forest fire events are ignored, then the daily maximums decline considerably, falling within a range of 5 to 9µg/m³. Based on the results gathered so far, it appears that $PM_{2.5}$ concentrations in Yellowknife are consistently low, with the greatest short-term influences being smoke from forest fires.

Because PM_{10} is a subset of TSP and heavily influenced by the same particulate sources like road dust, monitoring of PM_{10} levels provides an alternative, more complete and timely method to the Hi-Vol TSP sampling to track the impacts of dust in Yellowknife. Since the Hi-Vol only runs every six days, it potentially misses capturing high-level dust events occurring in between the six day cycle. However, the continuous monitoring methodology of the BAM ensures complete coverage throughout the year. In addition, the hourly sampling schedule of the BAM provides 'almost real-time' data and allows more detailed analysis of the typical 24-hour Hi-Vol sampling period.

The NWT has not adopted a standard for PM_{10}, but several Canadian jurisdictions (e.g. BC, Ontario, Newfoundland and Labrador) have adopted a PM_{10} concentration of 50µg/m³ (24-hour average) as an acceptable limit. Generally, starting in April, Yellowknife experiences several episodes of very high PM_{10} levels, which sometimes results in complaints from residents, prompting the City to initiate road sweeping ahead of their normal spring cleanup schedule. Overall, there were 12 exceedances of the 50µg/m³ limit in 2008 at the Sir John Franklin station, most of which occurred in April.

Figure 5: 2008 Yellowknife PM_{10}

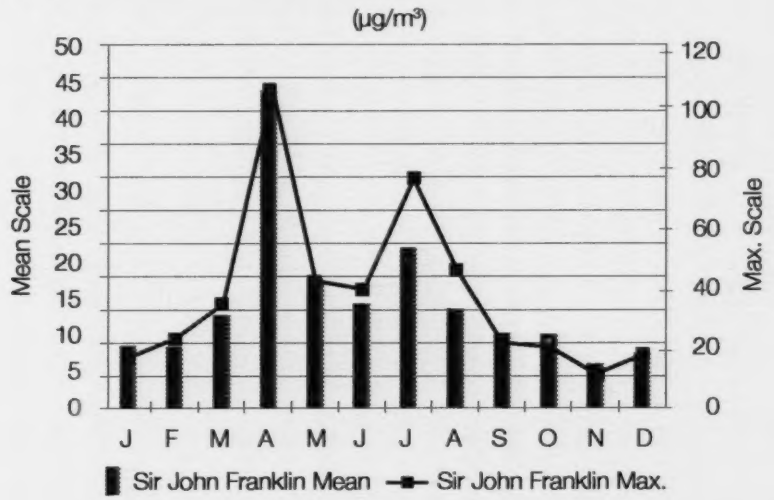


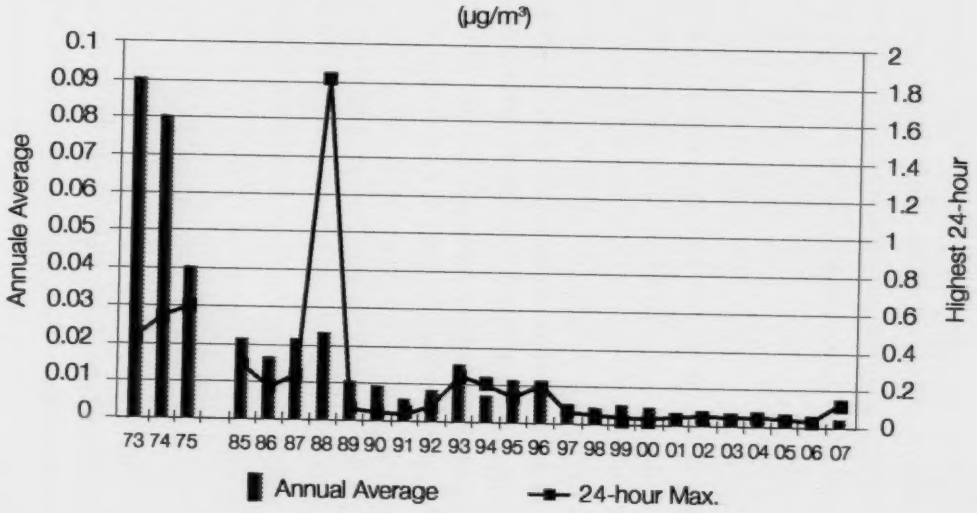
Figure 5 shows the PM_{10} monthly averages and daily maximums measured at the station in 2008. The highest daily maximum concentration was 105µg/m³, occurring in April, which correlates well with the Hi-Vol data. The highest hourly concentration recorded was 445µg/m³, also in April. The monthly average distribution in Figure 5 is similar to the distribution for TSP shown in Figure 2, indicating the close correlation between PM_{10} and TSP, and supporting the use of the BAM PM_{10} data to track the influence of road dust in Yellowknife.

Arsenic

TSP filters are analyzed to determine arsenic concentrations. Unfortunately, analytical delays at the NAPS laboratory often result in a one-year time lag between arsenic data and the annual air quality report. Consequently, arsenic data for 2008 is not available for inclusion in this report, although the 2007 data that was unavailable last year is. Analyses of the 2008 TSP filters will likely be completed by the end of June and results will be included in the 2009 Air Quality Report.

Figure 6 summarizes the historical concentrations of arsenic measured in Yellowknife up to 2007. The bars represent annual averages, while the line shows the highest total arsenic level measured over a 24-hour period for a given year. It is apparent that arsenic concentrations in Yellowknife have fallen from the historical, elevated concentrations in the 1970s and 1980s. No exceedances of the Ontario Guideline (0.3µg/m³) have occurred since 1988 and the average arsenic concentration over the last decade is 0.006µg/m³ – below all but the most stringent World Health Organisation (WHO) risk estimate concentration (see Appendix B). In recent years, the overall average has decreased further, to less than 0.003µg/m³.

Figure 6: Yellowknife Total Arsenic



The maximum 24-hour concentration in 2006 was 0.11µg/m³ – almost an order of magnitude lower than the Ontario Guideline. The annual average (geometric mean) concentration in 2007 was 0.002µg/m³, considerably lower than all but the most conservative risk estimate concentration provided by the WHO.

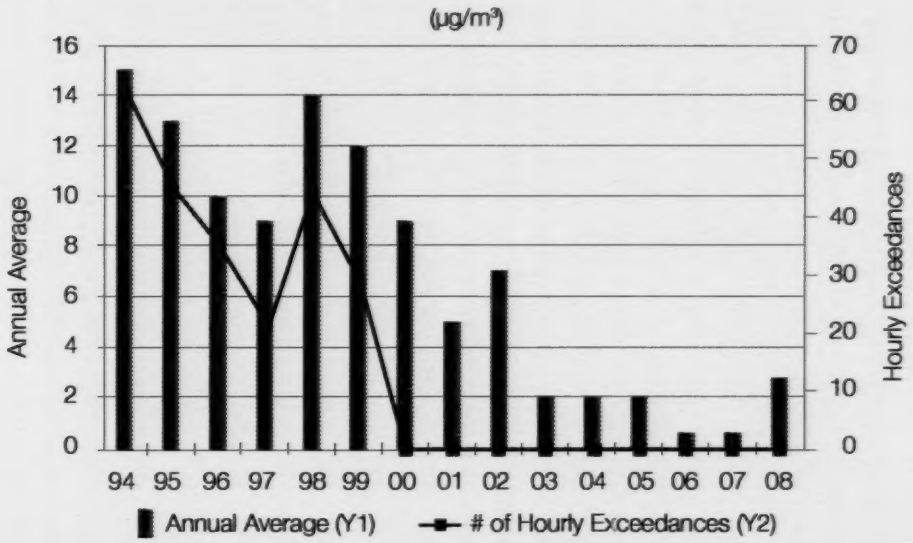
Studies in the United States show an average arsenic concentration in air of <0.001 to 0.003µg/m³ in remote areas, with concentrations of 0.020 to 0.030µg/m³ in urban areas, while Canadian urban areas range from 0.0005 to 0.017µg/m³ (WHO, 2000). Yellowknife arsenic results over the last decade indicate annual concentrations ranging from 0.002 to 0.015µg/m³ – comparable to concentrations measured in other urban areas. Since 1999, the levels have decreased and the annual average concentrations (0.002 to 0.004µg/m³) are similar to those in remote areas.

Based on the previous discussion, it appears that concentrations of airborne arsenic in Yellowknife are typical of those found in remote areas and that health risks due to inhalation are minimal.

Sulphur Dioxide (SO_2)

Continuous monitoring for SO_2 has been conducted in Yellowknife at several locations since 1992.

Figure 7: Yellowknife Sulphur Dioxide



In the past, the largest sources of SO_2 in the Yellowknife area were the gold mine ore roasters, the most recent being Giant Mine. The highest levels of SO_2 in the Yellowknife area were measured downwind from the mine. Since the mine was closed in 1999, only background levels have been recorded.

Figure 7 shows the general trends in SO_2 levels measured in Yellowknife air from 1994 to 2008. The bars track the annual average and the line shows the number of times in each year that the NWT one-hour standard was exceeded. As illustrated by the graph, the number of exceedances has fallen to zero since the closure of Giant Mine in 1999.

The 2008 data continued the trend of recent years, with a slight increase in the annual average. There were no exceedances of the NWT hourly (450µg/m³) and 24-hour (150µg/m³) standards. The annual average was less than 4µg/m³, a level well below the NWT (30µg/m³) standard.

The vast majority of the hourly concentrations recorded in 2008 were only background or slightly greater, with a maximum concentration of 13µg/m³. The concentrations reflect naturally occurring SO_2, usually in the range of 3 to 4µg/m³, and small amounts from the burning of fossil fuels.

Ground Level Ozone (O_3)

A continuous O_3 analyzer has been operating in Yellowknife since 1998. The current analyzer has been operating at the Sir John Franklin station since February of 2003.

Detectable concentrations of O_3 exist even in remote areas due to naturally occurring sources of the precursor gases such as forest fires and volatile organic compounds (VOC) emissions from trees and the introduction of stratospheric ozone to lower elevations resulting from atmospheric mixing processes. These background concentrations typically are in the range of 40 to 80µg/m³. In large urban areas (and areas downwind), ozone concentrations can be much higher than typical background due to the additional emissions of precursor gases (see Appendix B).

Figures 8 and 9 show the hourly and eight-hour maximums recorded for 2007 and 2008, together with the monthly averages. Neither the one-hour national standard nor the eight-hour NWT standard was exceeded in Yellowknife during 2007 or 2008.

Figure 8: 2007 Yellowknife Ozone

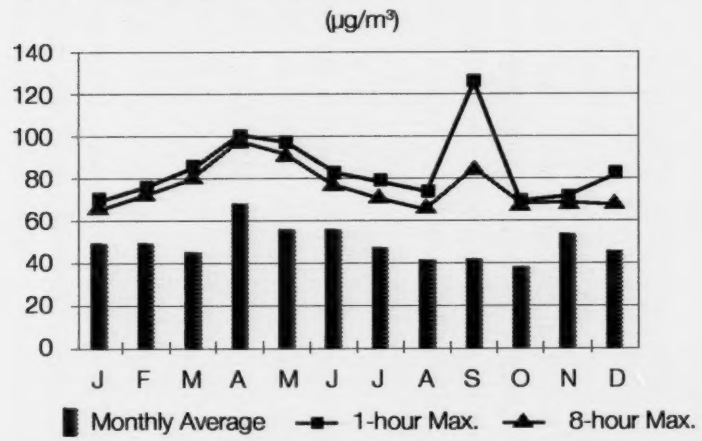
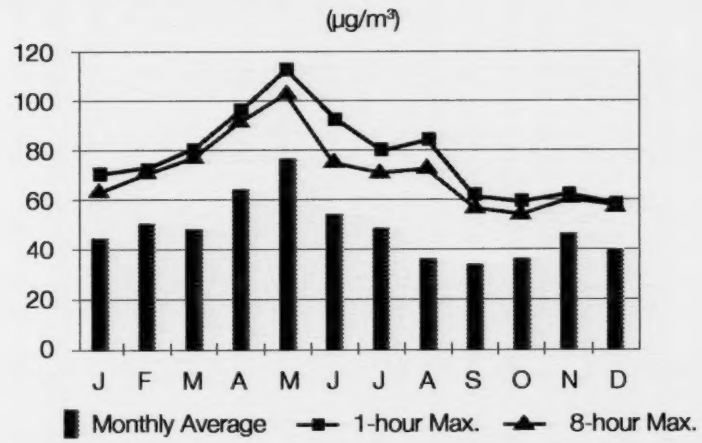


Figure 9: 2008 Yellowknife Ozone



The Figures illustrate the typical spring maximum, which commonly occurs at remote monitoring stations located in mid to high latitudes in the northern hemisphere and the source of which is the subject of considerable scientific debate. Typical monthly ozone concentrations at remote sites in Canada range between 40 and 80µg/m³, and Yellowknife concentrations for both years fell below or within this range, indicating that most of the O_3 detected is likely naturally occurring or background.

Nitrogen Oxides (NO_x)

The instrumentation provides continuous information on NO, NO_2 and NO_x. However, the focus is on NO_2 due to the greater health concerns associated with this pollutant and the availability of national air quality standards for comparison (see Appendix B).

The 2008 results indicated that there were no exceedances of the one-hour and 24-hour national standards for NO_2. The maximum one-hour average was 80µg/m³ and the annual average was 4µg/m³.

Figure 10: 2007 Yellowknife Nitrogen Dioxide

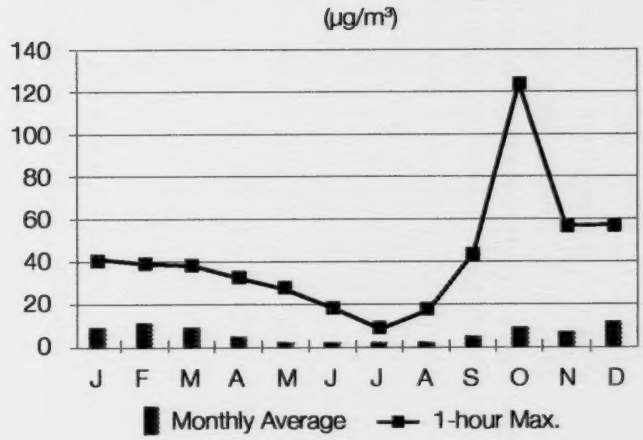
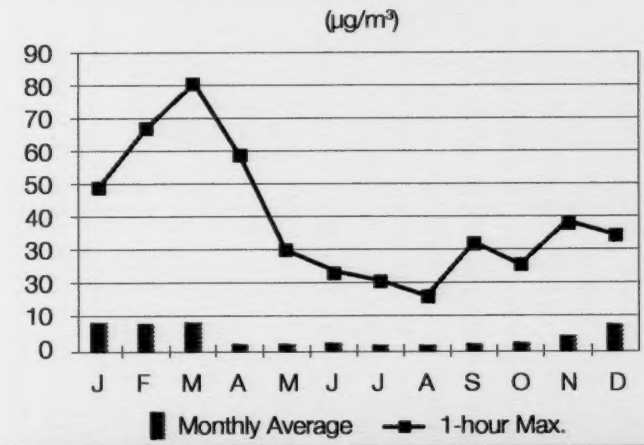


Figure 11: 2008 Yellowknife Nitrogen Dioxide

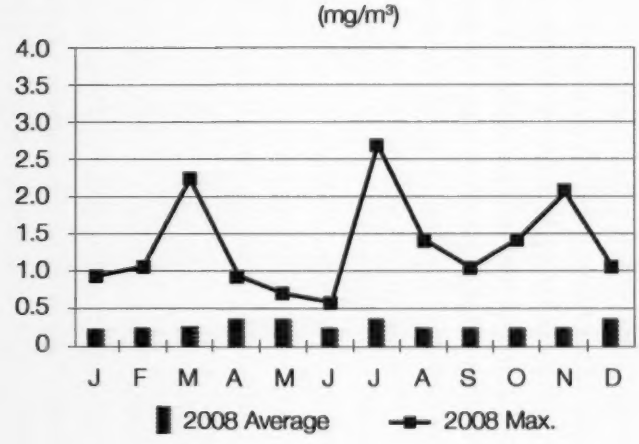


Figures 10 and 11 show the 2007 and 2008 monthly averages and highest hourly concentrations. Both the highest monthly averages and the highest hourly concentrations occurred during the winter months. This is likely caused by increased emissions from fuel combustion for residential and commercial heating, and idling vehicles, as well as short-term 'rush hour' traffic influences. The effects of these emissions on wintertime air quality can be increased when combined with stagnant meteorological conditions. Cold, calm days can result in an atmospheric situation where the normal decrease in air temperature with elevation is reversed and a zone of colder air is present at ground level. This zone of colder air and the lack of wind act to restrict dispersion and trap pollutants close to the ground.

Carbon Monoxide (CO)

The 2008 data continued the extremely low CO readings measured in 2007 and were well below the national standards (see Appendix B). Given the absence of heavy traffic volumes in Yellowknife, low levels of CO are expected. In 2007, the maximum one-hour average was 2.7 mg/m^3 and the annual average was 0.3 mg/m^3. Figure 12 shows the 2008 monthly averages and highest hourly concentrations.

Figure 12: 2008 Yellowknife Carbon Monoxide



INUVIK AIR QUALITY

The focus of the monitoring station in Inuvik is to gather baseline community air quality information and to track trends and cumulative effects of pollutant sources over time. In January 2006, the station was incorporated into the National Air Pollution Surveillance (NAPS) Network and also provides air quality information to this national monitoring network for comparison to other communities in Canada.

The station measures SO_2, H_2S, NO_x, O_3 , $PM_{2.5}$ and PM_{10}. Both the NO_x and the O_3 analyzers were supplied by Environment Canada (Yellowknife office).

Hydrogen Sulphide (H_2S)

The data collected in 2008 continues to indicate very low H_2S concentrations in Inuvik – essentially non-detectable. Most of the readings are less than 1µg/m³, which is below the detectable limits of the instrumentation and within the 'noise' range.

There were no exceedances of the Alberta Guidelines and the maximum recorded one-hour average was 6µg/m³.

Sulphur Dioxide (SO_2)

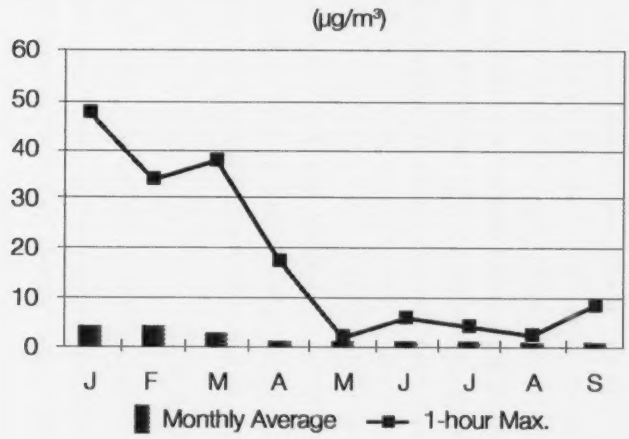
The SO_2 concentrations measured in 2008 were very low and similar to last year's results, with no exceedances of the NWT standards. The overall average was 2µg/m³ and the maximum one-hour average was 11µg/m³.

Nitrogen Oxides (NO_x)

As discussed in the Yellowknife section of the report, the focus of NO_x monitoring is on the NO_2 portion in determining air quality, although NO is certainly of interest for other reasons (e.g. assessment of secondary pollutant formation). The data collected in Inuvik in 2008 shows that there were no exceedances of the one-hour and 24-hour national standards for NO_2 (see Appendix B). The maximum one-hour average was 48µg/m³ and the annual average was 2µg/m³.

Figure 13 shows the 2008 monthly averages and highest hourly concentrations. Unfortunately, the analyzer suffered a serious breakdown in October, which necessitated lengthy repairs and resulted in no data collection for the last three months of 2008.

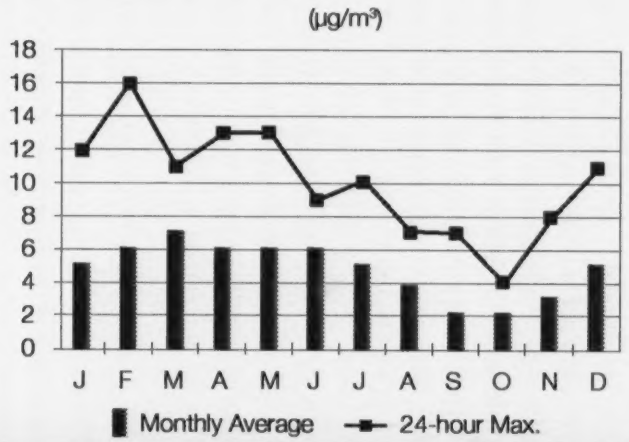
Figure 13: 2008 Inuvik Nitrogen Dioxide



As with Yellowknife, both the highest monthly averages and the highest hourly concentrations occurred during the winter months. Meteorological data collected over the last four winters has shown that Inuvik is prone to winter inversions and experiences more inversion days than the other three regions. It is not uncommon in the middle of winter to see consecutive days of extremely cold temperatures accompanied with very low wind speeds (calms), reducing dispersal of pollutants.

Fine Particulate ($PM_{2.5}$)

Figure 14: 2008 Inuvik $PM_{2.5}$



The 2008 BAM readings produced an annual average of 5µg/m³. There were no exceedances of the NWT standard for $PM_{2.5,}$ which was expected, as there were no significant impacts from forest fire events during the summer of 2008.

Figure 14 shows the monthly averages and daily maximums measured at the Inuvik station in 2008. The maximum 24-hour $PM_{2.5}$ value of 16µg/m³ occurred during the month of February and was associated with fine dust generated from construction in the area.

Coarse Particulate (PM_{10})

Figure 15: 2008 Inuvik PM_{10}

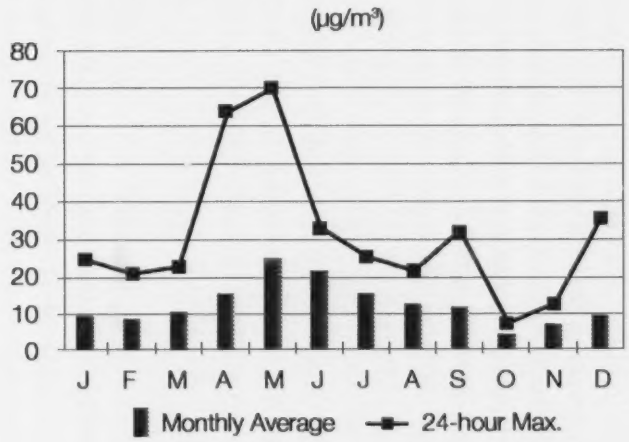
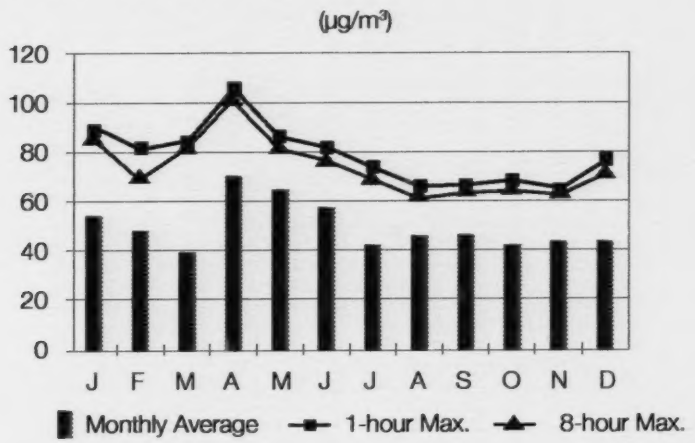


Figure 15 shows the monthly averages and the daily maximum concentrations. The highest daily maximum was 70µg/m³ recorded in May and there were three exceedances of the 50µg/m³ (24-hour average) acceptable limit used in other jurisdictions. In 2008, there was an obvious 'spring maximum' similar to that of Yellowknife. Unlike 2007, the springtime levels were elevated and were representative of the typical 'springtime dust event' associated with residual winter gravel. The highest hourly concentration recorded (189µg/m³) coincided with the highest daily maximum and occurred in May. The 2007 report stated that, "The summer monthly average values are similar to Yellowknife, but the daily maximums in Inuvik are somewhat higher, indicating a longer 'dust season' persisting throughout the summer months. This may reflect the greater percentage of unpaved roads and/or exposed areas in Inuvik providing a continuing source of dust throughout the spring and summer months. However, this speculation is based on only one year of complete data and it will be interesting to see if this pattern persists in future years." This pattern was not

evident in 2008 and is likely due to the re-locating of the station to a less than adequate location in terms of siting criteria. The station had to be re-located quickly and unexpectedly due to school renovations. The present location is temporary due to being somewhat enclosed and surrounded in three quadrants by buildings. A new approved site has yet to be determined.

Ground Level Ozone (O_3)

Figure 16: 2008 Inuvik Ozone



Neither the one-hour national standard nor the eight-hour NWT standard was exceeded in 2008. The typical 'springtime maximum' also occurred at this site and is consistent with the Yellowknife and Norman Wells stations, which also experience a peak in O_3 levels during the spring months.

Figure 16 shows the hourly and eight-hour maximums as well as the monthly averages recorded for 2008.

FORT LIARD AIR QUALITY

The focus of the monitoring station in Fort Liard is to gather baseline community air quality information and to track trends and cumulative effects of pollutant sources over time.

Hydrogen Sulphide (H_2S)

The maximum hourly H_2S concentration in 2008 was 3µg/m³ and the vast majority of readings were less than 1µg/m³, essentially within the detection limits or 'noise' range of the analyzer. H_2S in Fort Liard is, therefore, considered largely non-detectable.

Sulphur Dioxide (SO_2)

As in previous years, there were no hourly or 24-hour exceedances of the NWT standards in 2008, with a maximum one-hour average value of only 5µg/m³. The monthly averages were very low, with values less than 1µg/m³ – consistent with those measured over the last four years.

Elevated one-hour SO_2 values occur occasionally in Fort Liard, but these are rare, isolated peaks and still far below the NWT one-hour standard. Overall, the data indicates that SO_2 concentrations in Fort Liard are within the expected range of background values and there appears to be no impact on community air quality from oil and gas development in the area.

Fine Particulate ($PM_{2.5}$)

Figure 17: Fort Liard $PM_{2.5}$

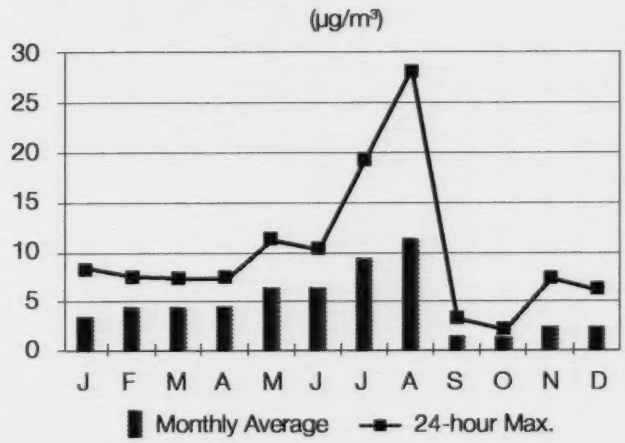


Figure 17 shows the monthly averages and daily maximums measured at the Fort Liard station in 2008.

The 2008 annual $PM_{2.5}$ average concentration was 4µg/m³, which is the same as the 2007 annual average. The maximum daily average was 28µg/m³, which reflects the fact that impacts from forest fire smoke were negligible in 2008. There were no exceedances of the NWT 24-hour standard for $PM_{2.5}$.

Coarse Particulate (PM_{10})

Figure 18: Fort Liard PM_{10}

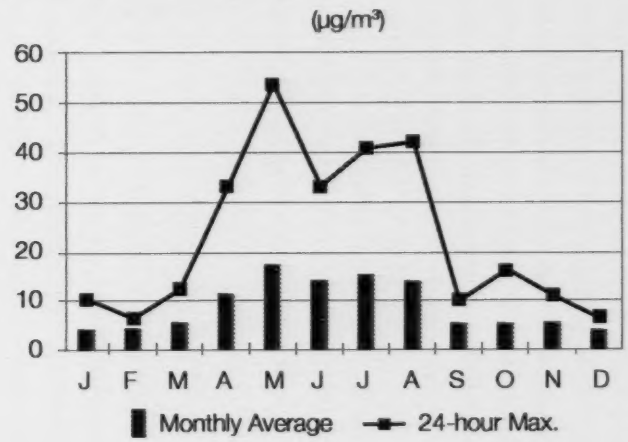


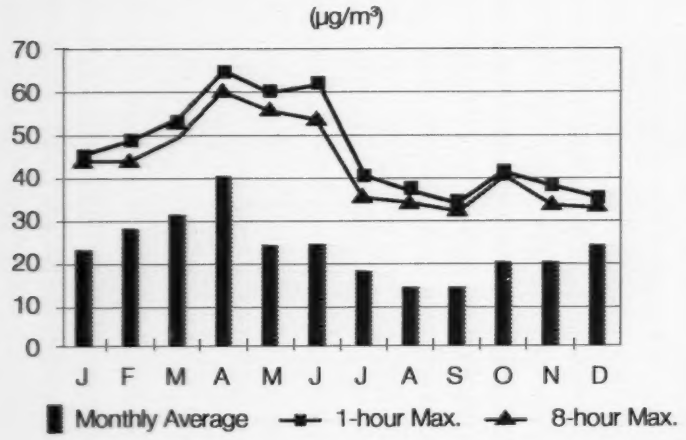
Figure 18 shows the monthly averages and the daily maximum concentrations. The highest daily maximum was 54µg/m³ recorded in May and it was also the only exceedance of the 50µg/m³ (24-hour average) acceptable limit used in other jurisdictions. In 2008, there was an obvious 'spring maximum' similar to that of Yellowknife and Inuvik.

Nitrogen Oxides (NO_x)

The analyzer was taken off-line in March following a major component failure. Attempts at on-site repairs were unsuccessful and it will most likely have to be replaced with a new unit while the original analyzer is shipped back to the manufacturer for repairs. The data collected for those first few months had to be invalidated once it was determined that the failure caused erroneous readings.

Ground Level Ozone (O_3)

Figure 19: 2008 Fort Liard Ozone



2008 represents the first full year that ozone data was collected at the Fort Liard station. Neither the one-hour national standard nor the eight-hour NWT standard was exceeded in 2008. The typical 'springtime maximum' also occurred at this site and is consistent with the Yellowknife, Norman Wells and Inuvik stations, which also experience a peak in O_3 levels during the spring months.

NORMAN WELLS AIR QUALITY

The focus of the monitoring station in Norman Wells is to gather baseline community air quality information and to track trends and cumulative effects of pollutant sources over time.

Hydrogen Sulphide (H_2S)

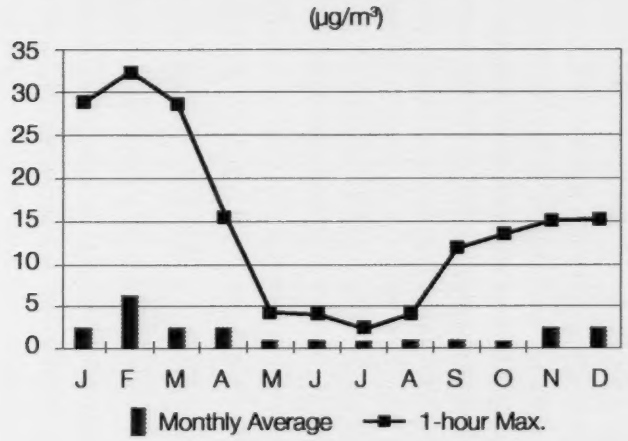
As in 2007, the 2008 data from the station continued to produce extremely low readings, with no exceedances of the Alberta Guidelines. Most hourly averages were essentially zero with a maximum one-hour concentration of 3µg/m³.

Sulphur Dioxide (SO_2)

The 2008 SO_2 monitoring program produced similar results to the Fort Liard, Yellowknife and Inuvik stations. The one-hour maximum was 5µg/m³. Overall, SO_2 concentrations were generally very low. The annual average was less than 2µg/m³ and no exceedances of the NWT standards occurred.

Nitrogen Oxides (NO_x)

Figure 19: Norman Wells Nitrogen Dioxide



The 2008 results show that there were no exceedances of the one-hour and 24-hour national standards for NO_2. As with the other three network stations, NO_2 levels increase in the winter months. The maximum one-hour average was 29µg/m³ and the overall average was 2µg/m³.

Figure 19 shows the 2008 monthly averages and highest hourly concentrations.

Fine Particulate ($PM_{2.5}$)

Figure 20: 2008 Norman Wells $PM_{2.5}$

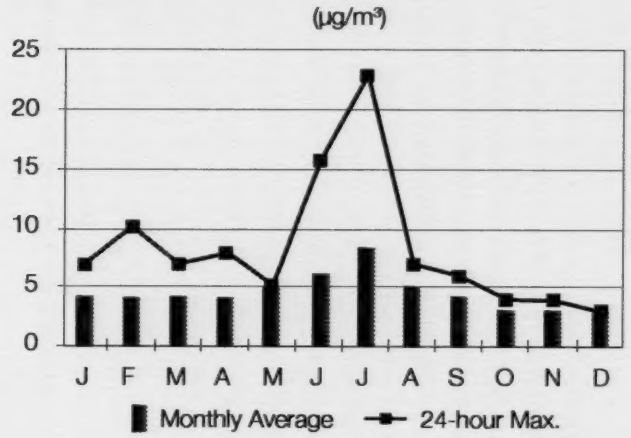


Figure 20 shows the monthly averages and daily maximums measured at the Norman Wells station in 2008. The maximum daily concentration was 23µg/m³ and the annual average was 5µg/m³. There was some slight long distance transport from forest fires, but impacts overall from forest fire smoke were negligible. There were no exceedances of the NWT standard.

Ground Level Ozone (O_3)

No exceedances of the one-hour national standard or the eight-hour NWT standard were observed in 2008. The elevated springtime levels were also evident at this site and are consistent with the Yellowknife and Inuvik stations, which also experience a peak in O_3 levels during the spring months.

Figure 21: Norman Wells Ozone

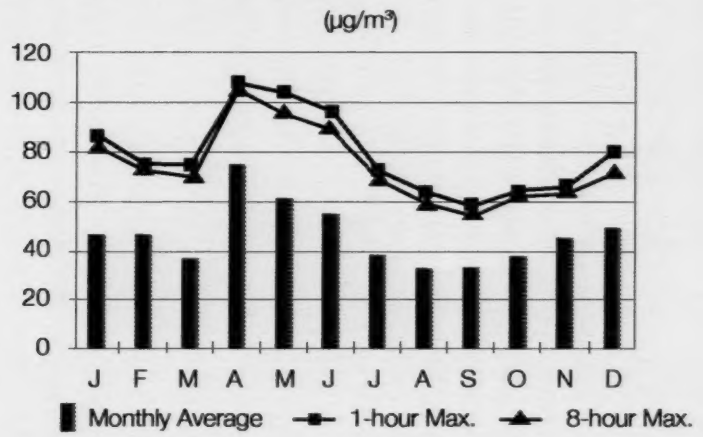


Figure 21 shows the hourly and eight-hour maximums as well as the monthly averages recorded for 2008.

SNARE RAPIDS

Since 1989, ENR has operated a Canadian Air and Precipitation Monitoring (CAPMoN) station at the NWT Power Corporation's Snare Rapids hydro site. This site is located 150 kilometres northwest of Yellowknife. Rain and snow samples are collected on a daily basis and sent to Environment Canada's CAPMoN laboratory in Toronto for analysis.

Acid Precipitation

Figure 22: Snare Rapids Acid Deposition

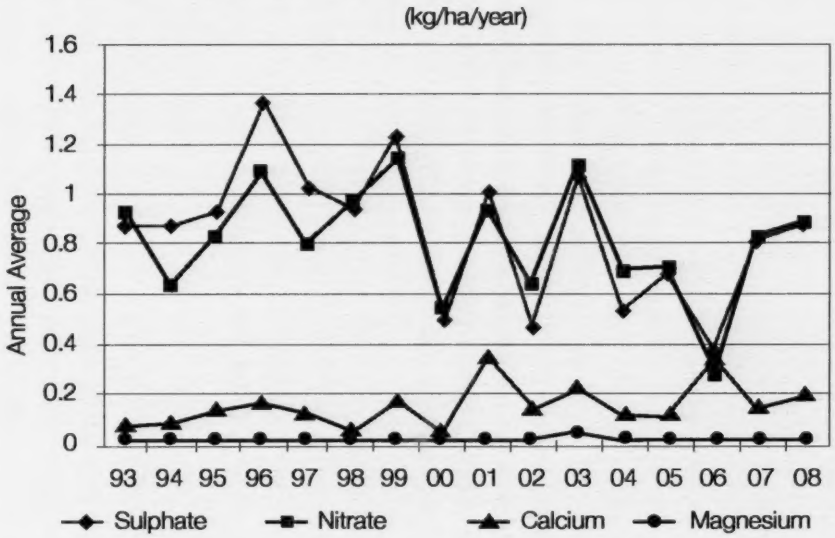


Figure 22 shows the deposition rates for sulphate, calcium, nitrate and magnesium from 1993 to 2008.

Seven kg/ha/yr sulphate is the level considered to protect sensitive ecosystems in the NWT. In areas of eastern Canada, where acid rain is a serious environmental problem, sulphate deposition is in excess of 20 kg/ha/yr. Nitrate deposition at Snare Rapids is similarly low compared to eastern Canada. Sulphate and nitrate deposition rates remain well below levels that could cause an environmental effect in sensitive ecosystems.

DARING LAKE SEASONAL PARTICULATE

In the summer of 2008, the short-term seasonal particulate monitoring program continued at the NWT Tundra Ecological Research Station located at Daring Lake. The program was a follow up to the PM_{10} monitoring program undertaken in the summer of 2002 and the $PM_{2.5}$ monitoring program in 2003 to 2007. The monitoring program in 2008 continued the focus on the finer portion of particulate $PM_{2.5}$. As in the previous five years, a battery operated Mini-Partisol particulate sampler and solar panel were set up to gather information on background concentrations of particulate in the barren lands. The 2008 sampling program began on July 11 and finished on August 21. The solar-powered system ran without incident in 2008.

A total of 13, 24-hour samples were obtained. The overall concentrations were similar to last year, ranging from 1 to 6µg/m^3. The 2008 results were typical of background levels and were not influenced by forest fires as in previous years.

APPENDIX A: MONITORING HISTORY

History of Air Quality Monitoring in the Northwest Territories	
1974	• Government of the NWT starts monitoring air quality in Yellowknife with the installation of a high volume air sampler at the Post Office site.
1989	• Monitoring of acid precipitation at the Snare Rapids hydroelectric site begins.
1992	• SO_2 analyzer installed at the City Hall site.
1997	• SO_2 monitoring in N'dilo begins and continues until 2000.
1998	• O_3 analyzer added in Yellowknife to the City Hall site.
2000	• A SO_2 analyzer was installed in the ENR building in Fort Liard in March, followed by a H_2S analyzer in October.
2002	• Daring Lake summer sampling of PM_{10} begins. • City Hall SO_2 analyzer relocated to new air monitoring trailer located at Sir John Franklin High School.
2003	• Daring Lake summer sampling of $PM_{2.5}$ begins (the same sampler is used for PM_{10} and $PM_{2.5}$ monitoring). • Air monitoring trailers are installed in Inuvik, Norman Wells and Fort Liard. • CO and NO_x analyzers added to the Yellowknife station as well as a continuous fine particulate sampler ($PM_{2.5}$). • Norman Wells station monitors SO_2 and H_2S. • Inuvik station monitors SO_2, H_2S, NO_x and $PM_{2.5}$. • Fort Liard station monitors SO_2 and H_2S. A $PM_{2.5}$ sampler is installed late in the year. • The O_3 analyzer that was operating at the City Hall location was relocated to the new Sir John Franklin Yellowknife station. • ENR initiates the upgrade of the Data Acquisition System moving to a specialized air monitoring system, which will allow more efficient and quality controlled data collection. • Continuous $PM_{2.5}$ samplers are installed in Inuvik and Fort Liard. • A second high volume sampler is installed at the Sir John Franklin Yellowknife station.
2004	• $PM_{2.5}$ sampler is installed in Norman Wells. • Data Acquisition System (DAS) is significantly upgraded. New components are installed inside the stations and a new data management, analysis and reporting system is brought on-line.

History of Air Quality Monitoring in the Northwest Territories (cont.)	
2005	• NO_x analyzer is installed in March at the Fort Liard station. • O_3 and NO_x analyzers are installed at the Norman Wells station in April. • O_3 analyzer purchased by Environment Canada (Yellowknife office) is installed at the Inuvik station in April. • Due to years of significant data loss caused by extreme cold, the Partisol Dichotomous fine particulate sampler at the Post Office station in Yellowknife is relocated indoors at the Sir John Franklin station. • The Yellowknife Post Office station is officially closed after the last TSP sample ran on December 6, 2005. • Development of an air quality web site begins. The web site will link with the data management, analysis and reporting system to provide public access to air quality data for each monitoring location. Access to archived data will also be available by querying the database using web-based tools.
2006	• Yellowknife – A BAM Particulate Matter (PM_{10}) monitor was installed and began collecting data in April. • Inuvik – A BAM Particulate Matter (PM_{10}) monitor was installed and began collecting data in October. • The Air Quality Monitoring Network web site was officially released.
2007	• Fort Liard – A BAM Particulate Matter (PM_{10}) monitor and an Ozone (O_3) analyzer were installed and began collecting data in late August. • Completed the second phase of the Air Quality Monitoring Network web site, which included database related modifications as well as web design improvements.

APPENDIX B: AIR POLLUTANTS

The NWT Air Quality Monitoring Network tracks a number of different air pollutants. With the exception of arsenic and H_2S, these pollutants are known as Criteria Air Contaminants (CACs). They represent the gases and compounds most often affecting community air quality and targeted by monitoring programs.

Arsenic is monitored in Yellowknife due to its association with metal ore roasting operations in the past and an ongoing concern during remediation work currently being undertaken at the former industrial sites.

H_2S is monitored at the air quality stations in Inuvik, Norman Wells and Fort Liard due to its association with oil and gas development activities.

Total Suspended Particulate (TSP)

Total Suspended Particulate (TSP) is a general term for dust. TSP includes a wide variety of solid and liquid particles found floating in the air, with a size range of approximately 50 micrometers (µm) in diameter and smaller (a human hair is approximately 100µm in diameter). While TSP can have environmental and aesthetic impacts, it is the smaller particles contained within TSP that are of concern from a human health perspective (see Particulate Matter ($PM_{2.5}$) and (PM_{10}) later in section). Road dust, forest fires, mining activities and combustion products from vehicles, heating and electricity generation contribute to TSP levels.

The NWT Ambient Air Quality Standard for TSP is 120µg/m^3) over a 24-hour period. The standard for the annual average is 60µg/m^3 (geometric mean).

Arsenic

Arsenic is present in the environment in a variety of forms. The most common form in air is the inorganic compound arsenic trioxide. Natural sources of airborne arsenic include volcanoes and windblown dust from arsenic rich soils, while industrial activities such as smelting and burning of coal account for most of the man-made sources. The vast majority of airborne arsenic is associated with dust and, therefore, analysis of TSP samples provides a good indication of arsenic concentrations.

There are no NWT standards for arsenic compounds. The World Health Organization (WHO) Air Quality Guidelines, (WHO, 2000), state that inhaling inorganic arsenic compounds can contribute to human development of cancer and there is no safe limit. It is, therefore, important to minimize exposure as much as possible, since the cancer risk increases with exposure to higher concentrations.

As the threshold for arsenic compounds has not been set, it is difficult to determine an acceptable level. Ontario continues to use a 24-hour guideline of 0.3µg/m^3 for total arsenic based on general toxicity, but the WHO suggest that a lifetime risk estimate approach should be used for assessment purposes. The WHO has calculated the following lifetime risk estimates of contracting cancer due to exposure to varying concentrations of arsenic in air:

- 0.066µg/m^3 results in a theoretical risk of one person in 10,000
- 0.0066µg/m^3 results in a theoretical risk of one person in 100,000
- 0.00066µg/m^3 results in a theoretical risk of one person in 1,000,000

In simple terms, the above estimates indicate, for example, that in a population of 10,000 people, a lifetime exposure to an arsenic concentration of 0.066µg/ m^3 could theoretically result in one person contracting cancer. The Ontario guideline provides a useful comparison for assessment of short-term (24-hour) arsenic measurements, but the WHO approach is probably more applicable given the longer-term health risks associated with arsenic exposure.

Particulate Matter ($PM_{2.5}$) and (PM_{10})

A sub-portion of TSP, these very small particulates are named for the diameter size of the particles contained within each group – PM_{10} contains particles with a diameter of 10 microns (1 millionth of a metre) or less, while $PM_{2.5}$ (a sub-portion of PM_{10}) contains particles with a diameter of 2.5 microns or less. The significance of these microscopic particles is that they can be inhaled and are associated with health effects, including aggravation of existing pulmonary and cardiovascular disease. Generally, the smaller the particle, the greater the penetration into the lung and the greater the associated health risk.

Sources of particulates that can be inhaled include road dust and wind blown soil, which make up the majority of the PM_{10} particles. Particles in the $PM_{2.5}$ size range primarily result from combustion of fossil fuels for industrial activities, commercial and residential heating as well as vehicle emissions, forest fire smoke and chemical reactions between other gases emitted to the air.

The national Canada-wide Standards (CWS) process has set an acceptable limit for $PM_{2.5}$, but has not yet established a limit for PM_{10}. The CWS 24-hour average acceptable limit for $PM_{2.5}$ is 30µg/m^3 and this concentration has been adopted under the NWT *Environmental Protection Act* as the NWT Ambient Air Quality Standard for $PM_{2.5}$. Several Canadian jurisdictions (e.g. BC, Ontario, Newfoundland and Labrador) have adopted a PM_{10} concentration of 50µg/m^3 (24-hour average) as an acceptable limit.

Sulphur Dioxide (SO_2)

SO_2 is a colourless gas, with a pungent odour at elevated concentrations, which can have negative effects on human and environmental health. Certain types of vegetation (especially lichens) are very sensitive to SO_2 impacts. SO_2 also plays a role in acid deposition and formation of secondary fine particulate through chemical reactions with other pollutants in the air.

There are some natural sources of SO_2 in ambient air (forest fires, volcanoes), but human activity is the major source. Emissions of SO_2 primarily result from the burning of fossil fuels containing sulphur. Sources include natural gas processing plants, gas plant flares and oil refineries, metal ore smelting, power generating plants and commercial or residential heating.

The NWT Ambient Air Quality Standards for SO_2 are 450 µg/m³ (one-hour average), 150 µg/m³ (24-hour average) and 30 µg/m³ (annual average).

Hydrogen Sulphide (H_2S)

Hydrogen sulphide (H_2S) is a colourless gas with a characteristic rotten egg odour. At high concentrations (parts per million range) it can be toxic, but typical ambient (outdoor) concentrations, even in areas impacted by industrial sources, tend to fall in the parts per billion (ppb) range. However, due to its low odour threshold, the presence of H_2S can be offensive and it has been associated with eye irritation and triggering feelings of nausea in sensitive individuals.

Industrial sources include oil and gas extraction, petroleum refining, sewage treatment facilities and pulp and paper mills. Natural sources include sulphur hot springs, swamps and sloughs, which release H_2S as a by-product of organic decomposition.

There are no NWT standards for H_2S. The Alberta Ambient Air Quality Objectives provide an hourly limit of 14µg/m³ (or 10ppb) and a 24-hour limit of 4µg/m³ (or 3ppb), based on avoidance of odour.

Nitrogen Oxides (NO_x)

Nitrogen oxides (NO_x) consist of a mixture of nitrogen-based gases, primarily nitric oxide (NO) and nitrogen dioxide (NO_2). Emissions of both NO and NO_2 results from the high temperature combustion of fossil fuels. The predominant emission is NO, which then rapidly converts to NO_2 through chemical reaction in the atmosphere. NO is a colourless and odourless gas, whereas NO_2 is a reddish-brown colour with a pungent, irritating odour. NO_2 is considered the more toxic and irritating of the two gases and, at elevated concentrations, is associated with both acute and chronic respiratory effects. Both gases play a role in the atmospheric reactions, resulting in acid deposition and secondary pollutant formation (i.e. O_3 and fine particulate).

Because of the greater health effects of NO_2, development of air quality standards has focused on this gas, rather than NO or total NO_x. There are no NWT standards for NO_2, but the national standards provide values of 400µg/m³ (one-hour average), 200µg/m³ (24-hour average) and 60µg/m³ (annual average).

Ground Level Ozone (O_3)

Ground level ozone (O_3) should not be confused with stratospheric O_3, which occurs at much higher elevations and forms a shield that protects life on the planet from the suns harmful ultraviolet radiation. The gas is the same but, at ground level, O_3 is regarded as undesirable due to its association with a variety of human health concerns, environmental impacts and property damage. O_3 is a highly reactive gas and is defined as a secondary pollutant. It is not emitted in large quantities from any source, but is formed through a series of complex chemical reactions involving other pollutants called precursors (e.g. NO_x and volatile organic compounds or VOCs) in the presence of sunlight.

The national standards provide a Maximum Acceptable Level of 160µg/m³ for O_3 based on a one-hour average. The Canada-wide Standards (CWS) process has also set an acceptable limit of 65ppb or 127µg/m³ based on an eight-hour average. The CWS eight-hour limit has been adopted under the NWT *Environmental Protection Act* as the NWT Ambient Air Quality Standard for O_3.

Carbon Monoxide (CO)

Carbon monoxide (CO) is a colourless, odourless and tasteless gas produced by the incomplete combustion of fuels containing carbon. The primary source is vehicle exhaust, especially in cities with heavy traffic congestion. Other sources include industrial processes and fuel combustion for building heating. One natural source is wildfires.

CO affects humans and animals by interfering with the ability of the blood to transport oxygen around the body.

There are no NWT standards for CO but the most stringent national standards provide a value of 15mg/m³ (one-hour average) and 6mg/m³ (eight-hour average). CO values are reported in mg/m³ as opposed to other gaseous pollutants, which are reported in µg/m³.

Acid Deposition

Acidity in precipitation is measured in pH units on a scale of 0 to 14. A value of seven indicates neutral, values less than seven indicate acidic conditions and values greater than seven indicate alkaline conditions. Even clean precipitation is slightly acidic – around pH5.6 – due to the presence of naturally occurring concentrations of carbon dioxide and minor amounts of sulphate and nitrate ions. The introduction of sulphur dioxide and nitrogen oxide emissions from combustion of fossil fuels for industrial, commercial and individual activities can result in an increase in acidic compounds in the atmosphere – often in areas far removed from the original emission sources. The removal of these sulphur and nitrogen compounds through atmospheric washout is reflected in the increased acidity (lower pH values) of precipitation. Calcium and magnesium ions – mostly from natural sources – act to neutralize acidity in precipitation.

Generally, precipitation with a pH value of 5.0 or less is termed 'acidic'. However, assessment of acid precipitation is usually based on deposition to an area over a specified time period (e.g. kilograms per hectare per year, kg/ha/yr) rather than review of specific precipitation event parameters. Also, the degree of impact to a particular environment is influenced by its 'buffering' capacity or ability to tolerate the acidic inputs. Therefore, determination of acceptable limits usually requires a range of values to reflect the differing tolerances of various areas.